

# Fault Detection System for Quality PCB Using CNN Model

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**ABSTRACT**

This paper presents a fault detection system for Printed Circuit Boards (PCBs) using Artificial Intelligence and Computer Vision. The system uses a modified YOLO-based Convolutional Neural Network (CNN) model integrated with Hornet, MCBAM, and CARAFE modules to detect defects in PCB images. The system captures PCB images, preprocesses them, and identifies defects such as short circuits, open circuits, and missing components. The implemented model provides high accuracy, real-time detection, and efficient defect localization using bounding boxes. The system improves quality control, reduces manual inspection effort, and enhances reliability in PCB manufacturing.

**Keywords** — PCB, Fault Detection, CNN, YOLO, Computer Vision, Defect Detection.

**I. INTRODUCTION**

Printed Circuit Boards (PCBs) are essential components in modern electronic systems. Due to increasing complexity and miniaturization, detecting defects manually has become difficult and time-consuming.

The developed system uses deep learning techniques to automatically detect defects in PCB images. It analyzes images using CNN models and identifies faulty and non-faulty boards. The system provides accurate, fast, and real-time inspection, reducing dependency on manual quality checks.

**II. LITERATURE REVIEW**

Various researchers have proposed PCB defect detection methods using image processing and machine learning.

Title of Paper	Objective	Limitations
Genetic Algorithm + NCC (Crispin et al.)	Detect PCB components	High computation time
Hybrid Genetic	Detect missing components	No classification

Algorithm (Mashohor et al.)		
Random Forest (Li et al.)	PCB segmentation	Moderate accuracy Random Forest
Template Matching (Yin)	Detect components	Limited flexibility

Most existing systems rely on traditional methods and lack real-time performance, accuracy, and automation.

The developed system overcomes these limitations using a deep learning-based YOLO model with improved architecture for better accuracy and speed.

**III. SYSTEM ARCHITECTURE**

The system consists of multiple modules working together. It starts with PCB image input, followed by preprocessing to enhance image quality. The processed image is passed to the CNN-based YOLO model for defect detection. The system identifies defects and marks them using bounding boxes. Finally, results are displayed to the user.

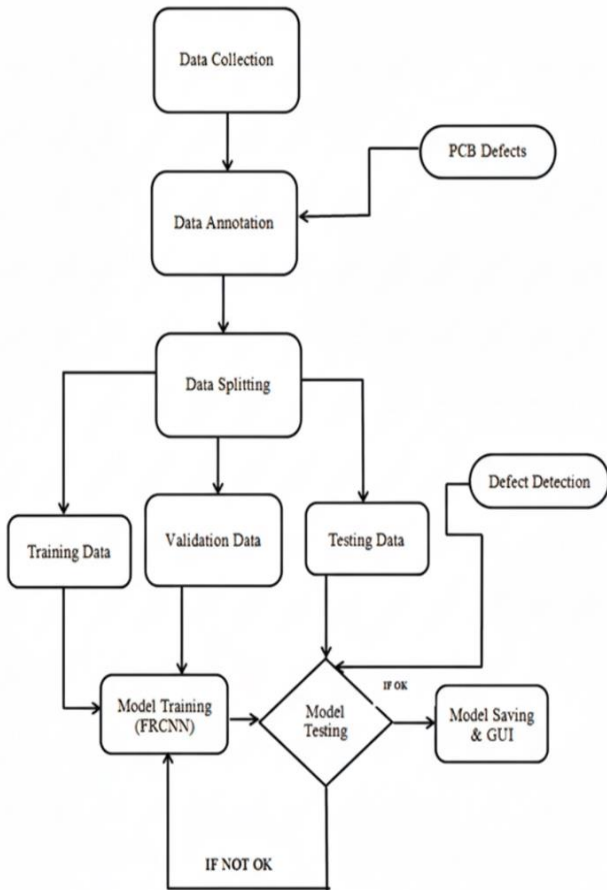


Figure 1: System Architecture

**IV. METHODOLOGY**

**4.1 Image Acquisition**

- PCB images were collected from datasets and real samples.

**4.2 Image Preprocessing**

- Preprocessing was applied to improve detection accuracy:
- Noise removal
- Image normalization
- Resizing
- Enhancement

**4.3 Model Implementation**

- A modified YOLO-based CNN model was implemented using:
- Hornet module
- MCBAM attention module

- CARAFE upsampling

**4.4 Defect Detection**

- The trained model detected defects such as:
- Short circuit
- Open circuit
- Missing components
- Mouse bite

**4.5 Output Generation**

- The system generated output by drawing bounding boxes around detected defects.

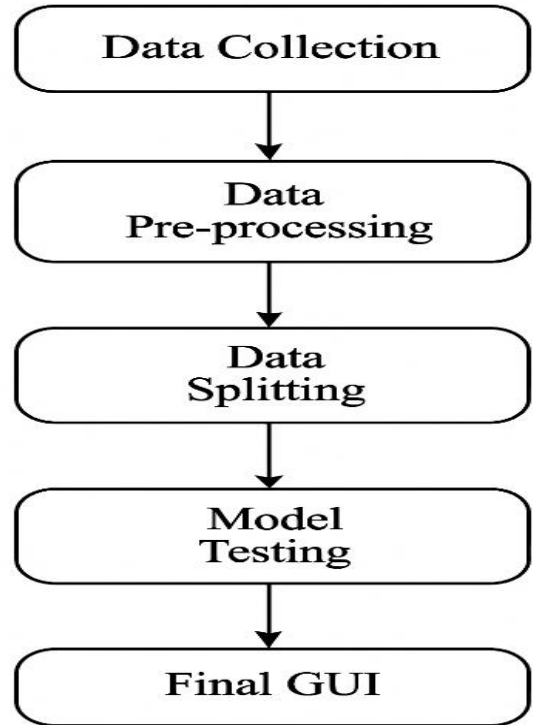


Figure 2: Workflow Diagram

**V. IMPLEMENTATION**

Software Tools	Hardware Requirements
<ul style="list-style-type: none"> <li>• Python</li> <li>• OpenCV</li> <li>• YOLOv8</li> <li>• TensorFlow / PyTorch</li> </ul>	<ul style="list-style-type: none"> <li>• Processor: Intel i5 or above</li> <li>• RAM: 8 GB</li> <li>• GPU (optional for training)</li> </ul>

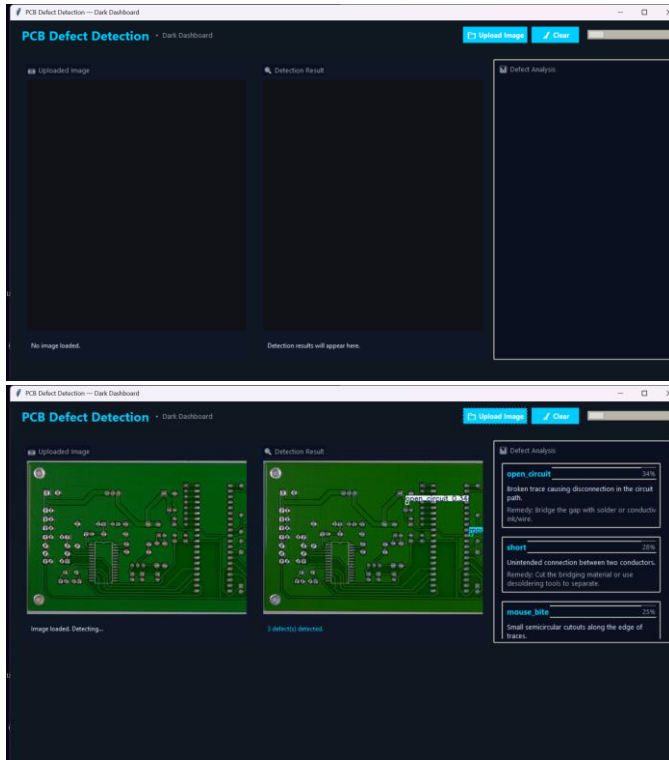


Figure 3: Application Interface

## VI. RESULT AND ANALYSIS

Parameter	Value
Accuracy	94%+
mAP Score	~98%
Recall	~95%
Processing Speed	~90 FPS

The system successfully detected and classified PCB defects with high accuracy. It provided real-time detection and precise localization using bounding boxes.

## VII. LIMITATIONS

- Performance depends on dataset quality
- Small defects require high-resolution images
- Training requires computational resources

## VIII. CONCLUSION

The PCB fault detection system was successfully developed using a CNN-based YOLO model. The system achieved high accuracy, fast detection speed, and real-time performance. It improves quality inspection, reduces manual effort, and enhances manufacturing reliability. The results confirm the effectiveness of deep learning in automated PCB defect detection.

## IX. FUTURE SCOPE

- Integration with real-time production lines
- Deployment on embedded systems
- Improvement in detecting ultra-small defects
- Cloud-based monitoring system

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